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REMEDIAL BIOLOGY

UNIT 4

TOPIC :

- **Plants and mineral nutrition :**

  Essential mineral, macro and micronutrients

  Nitrogen metabolism, Nitrogen cycle, biological nitrogen fixation

Plants and Mineral Nutrition

→ Mineral nutrition refers to the process by which plants absorb inorganic nutrients (minerals) from the soil and utilize them for their growth, development, and metabolism.

→ Plants require essential elements (minerals) for completing their life cycle and performing vital physiological functions.

Essential Elements

Element is considered essential for a plant if:

- It is absolutely necessary for the normal growth and reproduction of the plant.
- The deficiency of the element prevents the plant from completing its life cycle.
- The element cannot be replaced by any other element.

Classification of Essential Elements

Essential elements are broadly classified into two types :

Type	Required Amount	Examples
Macronutrients	Required in large amounts (more than 1 mg/g dry matter)	N, P, K, Ca, Mg, S, H, C, O
Micronutrients *(Trace Elements)*	Required in small amounts (less than 1 mg/g dry matter)	Fe, Mn, Zn, Cu, Mo, B, Cl, Ni

Macronutrients and Their Functions

Element	Functions
Nitrogen (N)	- Major component of amino acids, proteins, nucleic acids- Promotes leaf and vegetative growth
Phosphorus (P)	- Part of ATP, nucleic acids, and phospholipids- Important for energy transfer and root growth
Potassium (K)	- Maintains osmotic balance- Activates enzymes- Important in opening and closing of stomata
Calcium (Ca)	- Component of cell wall (calcium pectate in middle lamella)- Involved in membrane stability and enzyme activation
Magnesium (Mg)	- Central atom in **chlorophyll**- Activates enzymes for photosynthesis and respiration
Sulfur (S)	- Component of certain amino acids (cysteine, methionine)- Involved in synthesis of oils and vitamins

Micronutrients and Their Functions

Element	Functions
Iron (Fe)	- Important for chlorophyll synthesis (though not part of it)- Component of cytochromes (electron transport chain)
Manganese (Mn)	- Activates enzymes- Involved in photolysis of water during photosynthesis
Zinc (Zn)	- Required for synthesis of auxin (growth hormone)- Activates enzymes
Copper (Cu)	- Involved in redox reactions (cytochrome oxidase)- Important for lignin synthesis
Molybdenum (Mo)	- Essential for nitrogen fixation and nitrate reduction
Boron (B)	- Cell wall formation- Pollen germination and sugar transport
Chlorine (Cl)	- Involved in water splitting (photolysis) during photosynthesis
Nickel (Ni)	- Required for activation of urease enzyme (converts

	urea into ammonia)

Mechanism of Absorption

- As stated above it may be active or passive absorption.

Passive Absorption

→ Absorption by diffusion: The mineral molecules move by the principle of diffusion. i.e. from higher concentration to lower concentration and does not involve any use of energy by root cells.

→ Ion exchange mechanism: The process of exchanging negative ions (anions) and

→ Positive ions (cations) in the root cells by the ions of equivalent charge from the sail is known as ion-exchange process of passive absorption. The soil particles are negatively charged and to maintain the same these attract positively charged cations from the soil solution and the negatively charged ions are left free.

Active Absorption

- The ions find their entry into the root cells to accumulate in large concentration.
- These are then moved to the protoxylem by plasmodesma with the help of respiratory energy.
- The mechanism is explained by the presence of a carrier compound. The ions form ion-carrier complex.
- This complex gets in through the semipermeable membrane and again breaks into the ion of the carrier.
- The carrier compound again comes out of the root cells, combines with the new ions and the process goes on.
- This involves the use of metabolic energy.

Nitrogen Metabolism

→ Nitrogen metabolism is the set of biochemical processes by which plants absorb, assimilate, and utilize nitrogen for synthesizing essential molecules like amino acids, proteins, nucleic acids, and chlorophyll.

Nitrogen Cycle

➢ The Nitrogen Cycle is the natural circulation of nitrogen between the atmosphere, soil, plants, and animals. It includes several steps:

Steps of Nitrogen Cycle

Step	Description
1. Nitrogen Fixation	Conversion of atmospheric nitrogen (N_2) into ammonia (NH_3) by microbes or lightning
2. Nitrification	Ammonia is oxidized into nitrites (NO_2^-) and then into nitrates (NO_3^-) by nitrifying bacteria
3. Assimilation	Plants absorb nitrate or ammonium from soil and use it to make proteins and nucleic acids
4. Ammonification	Dead plants and animals are decomposed into ammonia by decomposer bacteria and fungi
5. Denitrification	Conversion of nitrates back into nitrogen gas (N_2) by denitrifying bacteria (e.g., *Pseudomonas*)

Importance of Nitrogen Cycle

- ✓ Helps plants to synthesise chlorophyll from the nitrogen compounds.
- ✓ Helps in converting inert nitrogen gas into a usable form for the plants through the biochemical process.
- ✓ In the process of ammonification, the bacteria help in decomposing the animal and plant matter, which indirectly helps to clean up the environment.
- ✓ Nitrates and nitrites are released into the soil, which helps in enriching the soil with necessary nutrients required for cultivation.
- ✓ Nitrogen is an integral component of the cell, and it forms many crucial compounds and important biomolecules.

Biological Nitrogen Fixation (BNF)

- Biological nitrogen fixation is the process by which atmospheric nitrogen (N_2) is converted into ammonia (NH_3) by certain prokaryotes using the enzyme nitrogenase.

Types of Nitrogen Fixation

→ **Atmospheric fixation :** A natural phenomenon where the energy of lightning breaks the nitrogen into nitrogen oxides and is then used by plants.

→ **Industrial nitrogen fixation :** Is a man-made alternative that aids in nitrogen fixation by the use of ammonia. Ammonia is produced by the direct combination of nitrogen and hydrogen, and later, it is converted into various fertilisers such as urea.

→ **Biological nitrogen fixation :** We already know that nitrogen is not usable directly from the air for plants and animals. Bacteria like Rhizobium and blue-green algae transform the unusable form of nitrogen into other compounds that are more readily usable. These nitrogen compounds get fixed in the soil by these microbes.